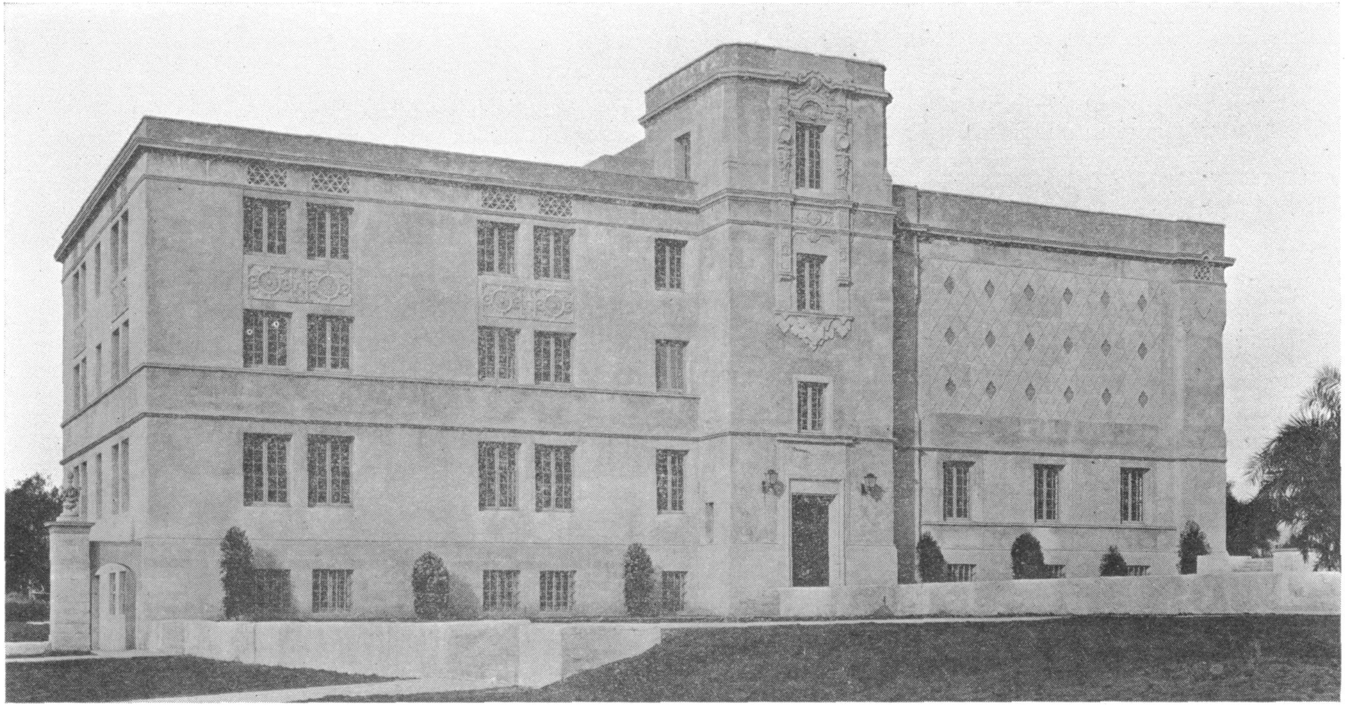

NORMAN BRIDGE LABORATORY OF PHYSICS

California Institute of Technology, Pasadena, California, which was recently dedicated. It is here that Professor R. A. Millikan and his associates are carrying on their important work on the constitution of matter. Professor Millikan is working in close cooperation with Professor Noyes of the Gates chemical laboratory and the astronomers of the Mt. Wilson Observatory. Professor H. A. Lorenz said at the dedication: "If some effect cannot be found on the earth the astronomers will look for it in the sun and if there is some new and not wholly understood phenomenon in solar physics, it will be reproduced and investigated in the Norman Bridge Laboratory."

THE PROGRESS OF SCIENCE[1]

STARS AND MOLECULES

THE range of research has been expanded in opposite directions and has opened up two hitherto unattainable regions, the minutest and greatest, the constitution of the atom and the constitution of the stellar universe. The two extremes meet in the method of investigation for the laboratory and the observatory have gone into partnership. The variations in the movement of the electrons in their orbits about the nucleus reveal the chemical relationships and reactions of the elements as well as the age and motions of the stars.

The laws that have proved useful in explaining the properties of gases are now found useful in interpreting the sidereal system. Dr. F. H. Seares, in a recent address at the Carnegie Institution of Washington, showed that the gas law of the equipartition of energy applied in general to the stars. The massive stars have the lowest velocities, while the smaller stars move more rapidly. Professor Seares says: "This equal distribution of the energy of motion can scarcely hold rigorously for the stars, since such a state can exist only when the motions are completely at random, which is not the case with the stars. Some of them move as groups, having motions which are parallel and equal. That it holds even approximately is surprising, for in a gas the state of equipartition is brought about by the collisions and close encounters of the molecules. But the stars do not collide, or at least so rarely that in practice we may consider that their motions take place without mutual interference. How then has the equal distribution of energy among the stars come about? We do not know; but obviously its existence is a circumstance that must be considered in any theory which pretends to account for the development of the stellar universe."

This peculiar behavior of the stars results from an extensive investigation of the masses, densities, and diameters of stars of all classes by Professor Seares, combined with recent measures of stellar velocity by Dr. W. S. Adams and his associates at Mount Wilson Observatory. When the stars are classified according to their intrinsic brightness or candle power and their temperature, it is found, as first shown by Hertzsprung and Russell, that the hottest stars do not differ widely in intrinsic brightness, but that among the cooler stars —those which are red—there are enormous differences in luminosity, amounting to 10,000 fold or more. And, what is more extraordinary, there is a gap between the two extremes of brightness, within which we find no red stars at all. We thus have the so-called giant and dwarf subdivisions of stars, a grouping which shows most clearly among the stars of lowest temperature, but persists to some degree through all the intermediate temperatures and disappears only in the case of the bluish white stars of high temperature.

The classification according to intrinsic brightness and temperature thus reveals two great divisions of stars, both of which run through the entire scale of temperatures: the giants which, roughly, are of the same order of brightness, all very luminous; and the dwarfs which merge with the giants among the very hot stars, but become fainter and fainter as we run down the temperature scale. Our sun is a typical

[1] Edited by Watson Davis, Science Service.

dwarf star of intermediate temperature, whose brightness is about 1/100 that of an average giant.

The study of astronomical processes in terrestrial laboratories has been made possible by the use of heavy currents of electricity. Dr. Gerald L. Wendt has by this means heated thin tungsten wires to the temperature of the hottest stars, some 50,000° F. and reports to the Chicago Section of the American Chemical Society and to the National Academy of Sciences that the metal is decomposed almost completely into helium. This, if true, would be a more complete and extensive disruption of the atoms than has been attained by Sir Ernest Rutherford, of the Cavendish Laboratory, Cambridge, who has obtained traces of hydrogen by bombarding the nucleus of nitrogen and other elements of low atomic weight with alpha particles.

Professor R. A. Millikan, of the California Institute of Technology, is also studying the constitution of atoms by bombarding with alpha particles, using his oil-drop detector to catch and count the ejected electrons. His method is to suspend in such a field a minute oil-drop, of diameter about one hundred thousandth of an inch, giving it just enough charge to neutralize the force of gravity upon it and therefore to keep it just suspended in midair tending to move neither up nor down. He then shoots alpha rays immediately underneath the drop and when one of these rays goes through a helium atom which is also underneath the drop and detaches from it an electron, the residue of this atom becomes thereby electrically charged and is thrown instantly upward by the field into the oil drop to which it sticks, thereby communicating its charge to that of the drop and changing the balance of the forces which had theretofore acted upon the drop. The result is that the drop begins to move upward at a speed which is proportional to the amount of charge communicated to it by the advent of the atom of helium upon it, so that if the alpha particle knocked out just one electron from the helium atom, the oil drop which instantly caught that ionized atom would begin to move upward with a speed which would be proportional to the value of this single electronic charge. But if the alpha particle had the good fortune to pick off both electrons from the helium atom as it shot through it, the charge communicated to the oil drop by the capture of the residue of the helium atom would then be twice as large as before and the motion would therefore be twice as rapid. By catching in this way the residues of ionized helium atoms at practically the instant at which they become ionized, it is possible to tell without the slightest uncertainty whether the alpha particle in shooting through the atom has knocked off just one of its electrons or both of them.

The results of Dr. Millikan's experiment are very interesting. He found that his alpha particles, which, it will be remembered, are moving with a speed very much faster than that of an ordinary bullet, *got both electrons every sixth shot*. That is to say, five shots out of six which got anything knocked only one of the two electrons out of the helium atom, but *on an average every sixth* successful shot knocked them both out. These facts throw some light on the structure of the helium atom, for they show that the two electrons in their revolutions around the nucleus of the helium atom must get into the same region of the atom a considerable portion of the time, otherwise they could not both get into the way of the alpha particle bullets as frequently as they are found to do. It is also interesting that Dr. Millikan has not yet found any atom save the helium atom, which loses more than one single electronic charge when an alpha particle is shot through it.